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OUTLINES

OF A

COURSE OF LECTURES

ON

METEOROLOGY,

ADDRESSED TO THE SENIOR CLASS

IN

YALE COLLEGE.

BY DENISON OLMSTED, LL.D.,
PROFESSOR OF NATURAL PHILOSOPHY AND ASTRONOMY.

1852.

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Newington
Jan 1862.

In the delivery of the
Outlines

OUTLINES
OF
LECTURES ON METEOROLOGY.

LECTURE I.

Of the Atmosphere in General.

DEFINITIONS, AND GENERAL DESCRIPTION OF THE ATMOSPHERE.

INTRODUCTION.—The most comprehensive view of the earth comprised under three heads, Geography, Geology, and Meteorology. Respective province of each.

Meteorology—Etymology of the term—definition.

OBJECTS OF METEOROLOGY.

1. General Description of the atmosphere in regard to constitution, extent, density, temperature, and color.
2. Relations to *Water*—whence the phenomena and causes of Dew, Fog, Clouds, Rain, Snow, and Hail.
3. Relations to *Heat*—whence, Climate, Ventilation, Winds, and Storms.
4. Relations to *Fiery Meteors*—whence, Thunder Storms, Aurora Borealis, and Meteoric Showers.

ADVANTAGES OF THE STUDY.

1. Practical—anticipations of the weather—the meteorologist and the sailor compared on this subject—knowledge of climate—of the laws of storms.
2. Philosophical—variety of phenomena—prevalence of laws, and uniformity of results of observations when accurate and long continued—a refined department of nature.

THE ATMOSPHERE. (ἄτμος and σφαιρα.)

1. *Constitution.* Permanent elements and proportion of each—variable ditto and amount of each. Whether these substances are in chemical union or mechanical mixture?
2. *Extent.* Height as deduced from twilight—from the phenomena of meteors—probable existence of an ethereal medium in space—small extent of the atmosphere, compared with the dimensions of the globe.
3. *Density.* Law of Mariotte—illustrated by the properties of the logarithmic curve—extreme rarity at great heights, as fifty and one hundred miles—extreme density of the column when continued downwards, as in a pit thirty-three and fifty miles deep.

4. *Temperature.* Diminished on ascending—at what rate?—Temperature of the Planetary spaces—manner in which the earth and lower regions of the atmosphere are heated—cause of the cold of high mountains.

5. *Color.* Whether the apparent color is real—how affected by elevation—by moisture—by vapors—Cyanometer.

6. *Perfection of properties* exhibited by the atmosphere in its elasticity and transparency; in respiration and combustion; in animal and vegetable life; in its buoyancy, fitting it for the habitation of birds, and for supporting the clouds; in its various mechanical agencies; in its relations to light and sound.

LECTURE II.

Of the Relations of the Atmosphere to Water.

NATURAL EVAPORATION AND DEW.

Introduction. Inquiries involved, viz: How vapor is raised into the atmosphere. In what state it exists there. How it is precipitated. Subjects comprehended under the relations of the atmosphere to water, namely: Natural Evaporation, Dew, Fog, Clouds, Rain, Snow, and Hail.

Natural Evaporation.

1. *Mode of Formation.* Vapor formed at all temperatures—different degrees of elasticity—doubles for every 27°—elasticity at 212°—cause of ebullition—elasticity of vapor at 32°. Amount of vapor raised into the atmosphere in different ways.

2. *Mode of Existence.* As an independent fluid. Dew Point defined—method of determining it—complement of the dew point—when the dew point is high—when low. How it leads to a knowledge of the actual quantity of water in a given quantity of air. How the atmosphere becomes heated and cooled—degree of dryness requisite to health.

Dew.

Cause unknown until investigated by Dr. Wells. His apparatus and mode of investigation.

1. *Leading Facts.* When dew begins to fall—when most copious—comparative quantities on clear and on cloudy nights—on still and on windy nights—on different substances equally exposed, as grass, naked sand, soils, bright metals, deep water, surfaces of living animals.

2. *Explanation.* Cause of dew in general—theory applied to each of the leading facts. Dew frugally distributed—evolves heat and not cold. Nature of *frost*—white frost and black frost formed on different principles.

LECTURE III.

Of the Relations of the Atmosphere to Water.

FOGS AND CLOUDS.

Fogs.

Difference in the mode of formation of fog and dew.

1. *Places* where fogs occur—none in tropical seas, abundant in polar seas—exemplified in the Gulf Stream—Fogs around icebergs—Fogs of Peru—Valleys and Marshes—Capes and Shoals—Banks of Newfoundland—sides of mountains—over rivers, particularly in a summer morning—Insular situations as Great Britain—Fogs of the Mississippi.

2. *Times* when fogs occur. In warm weather, chiefly confined to the morning. In cold weather, through the day. Transient fogs after sunrise. Fogs flow outward from rivers after sunrise. In winter dense fogs from the ocean winds.

3. *Explanation.* General cause—operates in two ways. First, by nascent vapor—these seen in a cold morning. Secondly, by the mixture of warm and cold air.

Phenomena explained—polar seas, Gulf Stream, icebergs, Peru, valleys, shoals, Banks of Newfoundland, mountains, rivers, islands, Mississippi—Fogs of summer, winter, transient morning fogs, outward flow from rivers, ocean winds.

Clouds.

How formed—Names—Four simple and three compound clouds—Height—Different strata—Indications of the weather afforded by clouds—Clouds capping high mountain peaks.

LECTURE IV.

Of the Relations of the Atmosphere to Water.

RAIN.

Anomalous character of the phenomena of Rain.

Leading Facts.

1. Places where it seldom or never rains.
2. Places where it rains continually.
3. Places where the rains are *periodical.*
4. Extraordinary *falls* of *rain.*
5. Comparative amount in *different countries.*
6. Ditto at different *heights* above the earth.
7. Rain *Maps* in the Physical Atlas.

Precipitation.

Form and sizes of drops of rain—when sustained—when precipitated.

1. Temperature. Diminished on ascending—at what rate?—Temperature of the planetary spaces—manner in which the earth and lower regions of the atmosphere are heated—cause of [illegible].

2. Color. [illegible] the apparent color is blue—how affected by [illegible] of vapor—[illegible].

3. [illegible] by the atmosphere in its [illegible] respiration, vegetation and combustion; [illegible] it for the life [illegible] in its various uses [illegible].

LECTURE IV.

On the Relations of the Atmosphere to Water.

VAPOR, EVAPORATION, AND DEW.

[illegible]. How vapor is raised [illegible]. In what state it exists there. How it is [illegible] considered under the relations of the [illegible], Natural Evaporation, Dew, Fog, Clouds, Rain, Snow, and Hail.

Natural Evaporation.

1. *Rate of Formation.* Vapor formed at all temperatures—[illegible]—doubles for every 27°—elasticity at 212°—[illegible]—elasticity of vapor at 32°. [illegible] the atmosphere in different ways.

2. *State of Existence.* As an independent fluid. Dew Point [illegible] method of determining it—complement of the dew point—when the dew point is high—when low. How it leads to a knowledge of the actual quantity of water in a given quantity of air. How the atmosphere becomes heated and cooled—degree of dryness requisite to health.

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2. *Explanation.* Cause of dew in general—theory applied to each of the leading facts. Dew [illegible]—bodies lose heat and not cold. Nature of frost—white frost and black frost formed on different principles.

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Phenomena explained—polar seas, Gulf Stream, icebergs, Peru, valleys, shoals, Banks of Newfoundland, mountains, rivers, islands, Mississippi—Fogs of summer, winter, transient morning fogs, outward flow from rivers, ocean winds.

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How formed—Names—Four simple and three compound clouds—Height—Different strata—Indications of the weather afforded by clouds—Clouds capping high mountain peaks.

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LEADING FACTS.

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2. Places where it rains *continually.*
3. Places where the rains are *periodical.*
4. Extraordinary *floods* of rain.
5. Comparative amount in *different countries.*
6. Ditto at different *heights* above the earth.
7. Rain *Maps* in the Physical Atlas.

EXPLANATION.

Form and *sizes* of drops of rain—when sustained—when precipitated.

Cause of rain in general—two modes in which the cause operates—effect proportional to the intensity of the cause—produced by the influx of either hot or cold winds.

Phenomena explained—Egypt—Peru and Chili—Deserts—Tropical countries as the West Indies—Guiana—Coasts of Coromandel and Malabar—Rio Janeiro—Cape Hatteras—Rainy Sea on the coast of Guinea.

Constant winds attended by fair weather—*variable* winds by rain. Examples.

Why winds from certain *quarters* are attended by fair, and from others by foul weather.

Signs of rain—threefold.

Prognostications of changes of weather.

LECTURE V.

Of the Relations of the Atmosphere to Water.

SNOW.

Subject treated under *three* heads—Natural History, Properties, and Uses of Snow.

NATURAL HISTORY.

Comprises the mode of formation, crystallization, and geographical relations.

1. *Mode of Formation.* Crystallized rain—dependent, in general, on the same cause as rain—temperature at which snow is formed—why "too cold to snow"—why it grows warmer just before a snow storm. Specific gravity of Snow—sometimes formed in the upper regions and melts in descending—Lunar halos.

2. *Crystallization.* Propensity of Nature to make things beautiful—geometry of Nature—crystallization of a dewdrop—varieties in the forms of crystals of snow—beauty of the figures under the microscope—uses of the crystallization—purity of snow-water.

3. *Geographical Relations.* Snow dependent either on the latitude or the elevation. Line of *latitude* irregular—course round the globe. Effects of *elevation*—why high mountains are covered with snow—glaciers—avalanches—icebergs.

PROPERTIES.

1. As a *non-conductor.* Its texture suited to this—this quality impaired when the snow is consolidated.

2. As a *non-radiator.* Effect of smoothness of surface—of color—Snow a warm substance—snow-drifts—Huts of the Esquimaux described—how lighted—Fire used for cooking—when these huts become most uncomfortable—minimum temperature of the external air. How the inhabitants obtain water.

Lec 6

Small kind. formed by warm gust of wind coming in –

Sec VI

9½ inch circum. by no means unprecedented
Clouds rush to a common center very fast —
usually 40 or 50 or 60 feet broad a few miles
long. One reached all through France &c
There is hail in winter but small kind of
hail — sometimes at night — but never violent —
. well known precursor of cold —

Seldom known in Torrid Zone — never in
Frigid. —

Construction

Nucleus of snow — bands like onions —
parallel — opake bands — thin transparent —

Causes —

Electricity will not explain all the
facts, not only inconsistent with fact
but inadequate to explain the phenomena it pretends. Volta supposes 2 clouds
one above the other — charged largely with
watery vapor — differently electrified. In
elevated region — nothing intercepts sun's rays
hence rapid evaporation, obj.

Heat derived from without can not
make it cool — may prevent warmth.
Hail stones formed on principle of [illegible]
rings — till acquire size enough to be drawn
by force of gravity to earth

USES.

1. *To imprison the heat of the ground*—analogy to clothing and furs—covering of polar animals—human clothing, in reference to texture and color. Freshness of grass and plants under snow—supposed fertility of snow—effect on the wheat crop—why the *air* is cold when the ground is covered with snow.

2. *Increases the amount of light*—favorable to the polar regions.

3. *Protects Rivers.*

4. *Retards the advance of winter and of summer.* Effects of the slow melting of snow—rapid vegetation when the snow has disappeared.

LECTURE VI.

Of the Relations of the Atmosphere to Water.

HAIL.

Two kinds—smaller kind easily accounted for—*hailstorms* the principal object of this lecture. Great size of hailstones.

LEADING FACTS.

1. Meeting of all the atmospheric elements in great *intensity*—out of the common course of nature.

2. Limited *extent*—breadth of hail storms—length of the path they traverse.

3. Occur in the *warmer seasons of the year*, and in the *hottest part of the day.*

4. Chiefly confined to the *Temperate Zones.* Especially frequent and violent in the South of France, Switzerland and Italy. Hailstorm in Mexico in 1830.

5. *Structure* and *different forms* of hailstones—foreign substances enveloped in them.

EXPLANATION.

1. *Electrical Hypothesis.* Former tendency to ascribe things to electricity. Inadequate to account for the facts—Volta's hypothesis. Absence of hail in the Tropical regions.

2. *True cause* assigned. Whence the origin of the cold? Region of Perpetual Congelation described—figure of the *curve* of congelation—height at the equator, at the tropics, at the latitude of 40°, and at the pole.

Two modes in which the cause may operate—meeting of hot and cold winds—ascent of hot and humid air by whirlwirds.

This theory applied to account for the facts—as the violence of the phenomena, limited extent, season of the year, occurring chiefly in the temperate zones, the peculiar figure of hailstones, and the foreign matters contained in them.

CONCLUSION.

Chain of connexion between all the phenomena arising out of the relations of the atmosphere to water, according as the cause acts with different degrees of intensity—when dew, fog, clouds, rain, snow, and hail, are formed respectively.

LECTURE VII.

REMARKABLE PROPERTIES COMBINED IN WATER.

INTRODUCTION. Riches of the Natural World inadequately comprehended—reason of this—how to acquire adequate views of this subject. Exemplified in a full review of the properties and relations of water under the several heads: Natural History, Chemical, Physiological, and Mechanical Properties.

NATURAL HISTORY.

Wide distribution of water. Six different sources enumerated.

1. *Extent.* Portions of the earth's surface covered by it.

2. *The Ocean.* Depth, saltness, motions producing waves, tides, and currents. Remarks on the currents of the ocean. Incidental advantages of this restless state of the ocean in distributing impurities and in promoting evaporation.

3. *Circulatory System of Waters.* Why the sea is not full, and why the land is not drained—circulatory system explained—Exemplified in the Mississippi river—Amount of water discharged by it annually—compared with the amount of rain that falls in the Valley of the Mississippi—quantity diminishing—why?

Purifying processes of nature in relation to water, by evaporation, crystallization, and filtration. Structure of the upper surface of the earth favorable. *Artesian Wells* described—their maximum depth. *Rivers*—ultimate purpose but important incidental benefits. Water considered in relation to *commerce*—in relation to marine *animals*—as an element of *natural scenery.*

CHEMICAL PROPERTIES.

Nature of these as distinguished from other properties.

1. *Composition.* Importance of its elements—extent to which they severally prevail in nature. Possibility that water may supply the place of fuel.

2. *Chemical Relations.* So numerous that the ancients regarded it as one of the primordial elements—important agencies in acidification, fermentation, and spontaneous decomposition—general *solvent*—hence extensive use in the arts—discriminating in what it dissolves—this property wisely limited in its spontaneous action, but can be greatly exalted by man—use as a *detergent.*

3. *Different Chemical States.* Ice, snow, water, and vapor. The transmutations existing between these, regulate the temper-

Lec 7

Nat. History L. E. external appearance -

6 sources. 1st ~~Atmospheric vapors.~~

3/4 of ~~earth~~ covered with water.

Depth. La Place Atlantic 9 miles.

Our gov. sounded 6½ miles deep.

Saltness is believed to have originated first by salt carried down by rivers.

3½ per ct salt saltier in warm than in cold climates

waves to height of 38 feet.

15 billions cubic feet emptied annually in Gulf of Mexico by Mississippi —

Quantity is diminishing because as a country becomes cleared the evaporation is greater.

So called from Artway when first dug 24100 feet.

Ganges descent 3 inches per mile

Croton water sinks foot a mile —

Sperm whales are supposed to go to the bottom of the ocean —

Lecture VIII.

Thermometer. 7000 observations made at Toronto mean 44° ac

New York requires all Academies to keep record of weather. Massachusetts God bless her, has done the same.

Enable to investigate the laws of storms.

Thermometer.

1 To get a good one. Kendall's most common one. Not sufficiently accurate for science — do for rooms — want accurate or minute graduation. — Another fault shut up at bottom. Greene's of New York may be fully relied on ~~[illegible]~~ near Canal St.

~~Selection~~ Place of exposure

Temperature may be affected 10° by building should never be in contact with building. Guyot says they should project 3 feet. bulb ought to be guarded from reflection. screen it ature of the globe. Ice protects the rivers, and snow the land, while vapor performs great agencies in the atmosphere.

PHYSIOLOGICAL PROPERTIES.

Physiology respects *living* matter—hence these properties constitute the relations of water to the animal and vegetable kingdoms.

1. Relations to *Vegetables.* Food of plants—medium of other kinds of nutriment. Its fertilizing effects in different forms.

2. Relations to *Animals.* As a beverage—as the means of preparing food—as a medicine—in many subordinate ways.

MECHANICAL PROPERTIES.

1. Its *Mobility*—uses of this property.

2. *Buoyancy*—whence its relations to fishes and the art of navigation.

3. Its *Pressure*—whence the hydraulic press and other mechanical engines.

4. Its *Momentum*—whence it becomes a repository of mechanical power of various degrees of intensity.

5. Its convertibility into *Steam.* Important offices steam performs for man.

LECTURE VIII.

Of the Relations of the Atmosphere to Heat.

METEOROLOGICAL INSTRUMENTS AND OBSERVATIONS.

INTRODUCTION. Four important subjects arising out of the relations of the atmosphere to heat, namely, Climate, Ventilation, Winds, and Storms. As a foundation for the whole, and important to all parts of meteorology, necessary to premise some account of meteorological instruments and observations. Necessity of observations in order to ascertain the laws of atmospheric changes—greater accuracy now than formerly—rewarded by finer results—simultaneous observations at the equinoxes—useful objects proposed.

THERMOMETER.

1. *Rules for selectiny a good one.*

2. *Place of Exposure.* How to guard against sources of inaccuracy—proper height from the ground.

3. *Times of Observation.* Object to arrive at mean results—how to find very accurate means by hourly and half hourly observations—what *two* observations may afford a proximate mean? Result obtained at Toronto for two successive years. *Three* observations particularly recommended. *Critical Hours* defined—Results obtained at Leith Fort for three successive years—*inter-*

vals between the critical hours of morning and evening the same in different places.

4. *Range of Temperature.* Highest and lowest natural temperatures—entire range—small range in tropical countries, as at Honolulu—range for the United States—for London—for St. Petersburg—for Montreal—for New Haven. *Isothermal Lines.*

Barometer.

1. *Rules for Selection.*
2. *Place of Exposure, and Times of Observation.*
3. *Corrections.* For temperature—for capillarity—for difference of level.
4. *Indications of Weather.* When the barometer is falling—when rising—when stationary—when there is a sudden and extraordinary rise or fall. Great value of this instrument—especially to the navigator.

Hygrometer.

Object—construction—varieties. Daniel's hygrometer—Uses—importance in regard to changes of weather and salubrity of climate. Also the amount of watery vapor contained in the atmosphere.

Rain Gage.

Form and construction—place of exposure—how to estimate the amount of rain and other watery precipitations.

LECTURE IX.

Of the Relations of the Atmosphere to Heat.

CLIMATE.

Definition.

The condition of a place with respect to all the meteorological phenomena. Permanency of the temperature of the globe.

General causes affecting the Climate.

1. Latitude. Effect as the square of the cosine. Comparative lengths of the days and nights. Elevation of the sun above the horizon in different latitudes. Thermometer falls 1° for every degree of latitude.
2. Elevation. Fall of the thermometer on ascending into the atmosphere. Number of feet corresponding to 1°. Successive climes met with on ascending high mountains in warm countries.
3. Influence of Water. Effect of humid and dry air on our sensations—upon the salubrity of a place—standard of agreeable temperature higher in a warm country.

About 7 feet high — Guyot 10 feet — triply or about
3 times of ob — before sunrise minimum
afternoon from 2 to 3 maximum — 2 added
together divided by 2 gives daily mean —
~~6~~ 9 A.M., 3 P.M., 9 P.M. — added together
divide by 3 gives mean —
Mr Guyot 6 AM 2 PM 10 P.M,
Critical hours or when thermometer stands
at ~~hour~~ mean ~~temperature~~. At Leith
9.13 in 2d year 9.14 in — 8d yr 9.13 at
every country critical hours ~~[illegible]~~ different
difference in interval the same everywhere.
Highest of air ever measured 130° in Upper
Egypt. Lowest — 59½ below zero. coolest in
Northern Regions. At no one place do we observe
this range. Highest in N. Haven 96 taken fairly
Lowest 25 below zero. 120 degrees range for
Newhaven. Franconia N.H. highest. London rarely
below 40°. seldom rises above 80°.
Boston = St Petersburg in winter, In equator
varies with latitude.

Barometer may be hung in entry Prof Brocklesby work gives directions how to rectify it.

Lecture 9.

Climate is the condition of any place with respect to meteorological phenomena

M Arago found that the temperature had not varied.

Winter at Melville Island.

In Baffins Bay. in polar circle -

Day. Sun rises 15° above Southern

Horizon. At autumnal equinox;

5 Nov disappear 96 ds out of sight.

Aug. winter comes on —

Aug & Sept snowy months — Ice 7 ft thick

Conversation could be heard a mile

100 buckets of ice from condensed breath

in 4 weeks —

Lecture X (10)

Climate of the Torrid Zone.

Of small Islands—of the sea coast—of continents—of interior plains—table lands—mountains.

Climate of the Frigid Zone.

Winter at Melville Island, Lat. 74° 40′. Successive positions and aspects of the sun, commencing with the equinox—altitude at noonday—wholly disappears Nov. 5th. Long twilight—noonday at the winter solstice. *Conservative* powers of nature put forth—heat of congelation—snow—moonlight—aurora borealis. *Polar phenomena*—rending of the ice and rocks—audibility of sound—ordinary and extraordinary degree of cold—accumulation of ice on the walls of a ship's cabin—Density of smoke issuing from a chimney. Thickness of the ice and depth of the snow—general aspect of desolation.

Relations of Climate to Organic Nature.

1. To Vegetables. Succession of plants as we ascend the Alps. Vegetation in the Torrid Zone—in the Frigid—floral calender.

2. To Animals. Peculiarities of the animals of hot and cold climates—of hot and humid, or hot and dry countries. Polar animals, especially of the Polar Seas. [illegible]

LECTURE X.

Relations of the Atmosphere to Heat.

VENTILATION.

Introduction. Increasing interest in this subject—facilities afforded by nature—conservative efforts of nature—tendency in writers on Ventilation towards the exquisite—latitude allowed by nature to people in health in respect to temperature, clothing, diet, and air.

Definition.

The art of producing a free circulation of pure and wholesome air. Object to supply pure and fresh air to dwelling houses, crowded rooms, hospitals, and prisons. Amount of fresh air required for each individual per minute.

Sources of Contamination.

1. Respiration—Changes produced by it on air.
2. Insensible Perspiration. Its amount and unwholesome qualities.
3. Lamps, candles, and gas lights—products of their combustion.
4. Artificial fires and manufactories.

5. Effects of extreme contamination as witnessed in crowded rooms, slave ships, and the Black Hole of Calcutta.

METHODS OF VENTILATION.

1. In the structure of houses. Fumes of the kitchen—drainage. Effect of an excess of trees and shrubbery.
2. By air flues, and chimneys.
3. Special rules for ventilating dwelling houses, school houses, churches, hospitals, and prisons.
4. Methods of Ventilation adopted in several public buildings, as the British House of Commons.

LECTURE XI.

Relations of the Atmosphere to Heat.

PRACTICAL MANAGEMENT OF HEAT.

INTRODUCTION. Labors of Dr. Franklin and Count Rumford. Most improvements in the art of warming the result of science.

CHIMNEYS.

1. Draught of a chimney—principle on which smoke ascends —circumstances which favor the draught or impede it—Causes and Cure of smoky chimneys.

FUEL.

1. Comparative value of different sorts of *wood*—degree of seasoning—under cover. When *green* wood may be burned economically.
2. Comparative value of different kinds of charcoal—ditto of anthracite coal. In what cases fuel that affords much *flame* is preferable.
3. What kind of fuel is most favorable to *health.*

STOVES.

Advantages and disadvantages of different kinds, in reference to economy, health and convenience. Qualities of a perfect stove.

Air-tight stoves and drums considered in regard to ventilation.

FURNACES.

Good and bad qualities—importance of lining with non-conductors—of affording more or less heat at pleasure. Temperature most suitable for apartments, for halls, for sleeping rooms.

Questions Answers

Lec XI.

2 most practical philosophers.

1 Chimneys.

Draught of chimneys

carried up mechanically by the ascending column of air. Smoke is heavier than air. Every thing that tends to keep ch. warmer diminish friction facilitates ascent of smoke.

2 Material. 3 form 4 why crooked impedes smoke

5 why smoke in damp day? Why running chimney improves it. Why in center better than outside. Why smoke with wind in different directions.

1 why Brick. best non conductors. better in double layers because get cold quicker.

3 straight chimney best - cause less friction. Dampers cools the current before it can ascend. A chimney won't draw with snow in it because snow must be liquefied absorbs 140° then turned to vapor 1000° more

Burning improves 1st great collection sometimes diminishes column too much -

2 Chief reason improper causes friction -

11 Fuel. Hickory shagbark used to 81 —

My stove went into disuse because I preferred to study nature — when I invented my stove I was a backslider. In 1836 it smashed up —

Furnace auxiliary

Lecture 12th

Lieut Maury has constructed wind chart. Prof Coffin has compared winds in 576 differt places from equator to 85° of latitude —

Results — 1st winds are regulated by law — not a wave rolls — not a breeze blows not a leaf blows — but by law — If air grows cool or warm, wind blows — It condenses just right it snows — ~~And~~ At Burning of Moscow wind blew so that wherever French went they ~~[illegible]~~ felt a whirl wind on their nose.

Relation wind —

Opposite currents at different elevations — When a portion of fluid runs in ~~[illegible]~~ one direction it runs in other — It cannot run in one direction without it runs in other. General Principles relation air same as in earth.

Limits of calm & trade winds have been definitely ascertained

Equator calm — more north of Eq than South because Southern trade wind overpowers north —

LECTURE XII.

Of the Relations of the Atmosphere to Heat.

WINDS.

Introduction. Necessity of interpreting nature on a great scale—thus her laws discovered. Air set in motion by any thing that disturbs its equilibrium.

Causes of Winds.

1. *Change of Temperature.* Burning of Moscow. Whirlwinds produced by artificial fires—Burning of a Cane-brake in Alabama—Land heated and cooled more easily than water—hence land and sea breezes and hurricanes of tropical islands. Calmness of the Pacific Ocean.
2. *Displacement of air,* by the swift passage of great bodies, as water-falls—avalanches—falling in of coal mines—meteors—comets.
3. *Relative Winds*—produced by our passing rapidly through the air. Effect of change of latitude combined with the earth's diurnal motion.
4. *Opposite currents,* at different elevations. Tendency of one current to give rise to another in the opposite direction.
5. *Tendency of fluids to circular motion.* Whether winds flow uniformly in a *rectilinear* direction?

General Laws.

1. General tendency of the winds within the latitude of 30° on both sides of the equator.
2. Tendency between the latitudes of 30° and 70°.
3. Beyond the latitude of 60°.
4. Amount of winds blowing to and from the equator respectively.
5. Winds that meet the land from the ocean compared with those that flow over the land, in respect to temperature.

Particular Winds.

1. *Trade Winds.* Description—cause.
2. *Monsoons.* Prevail in the Indian Ocean. Phenomena and cause.
3. *Hot Winds.* Sirocco, Harmattan, Solano. Properties when they blow over deserts and over water respectively.

LECTURE XIII.

Of the Relations of the Atmosphere to Heat.

VIOLENT WINDS.

(A) Sublime phenomena, and great exhibition of power. Force at different degrees of velocity. Momentum on a square foot at 10 miles per hour, and law of increase. Immense force at 300 miles per hour. Scriptural allusions to violent winds.

Varieties.

(B) 1. Hurricane, gale, tornado, and whirlwind distinguished from each other.

2. *Tornadoes.* Of Shelbyville—Natchez—Stow—New Brunswick—New Haven.

Classification of Facts.

(C) 1. *Fall of the Barometer*—sultry heat preceding.

2. *Extraordinary Cloud.* Different appearances in different storms.

3. *Suddenness.* Usual duration—greatest duration, when most violent.

4. *Violence.* Trees torn up by the roots—houses demolished—steamboats and ships lifted from their beds—plank driven into walls and into the ground—people transported to a distance—fowls singularly affected. Houses burst outwards.

5. *Dimensions.* Usual limits of land tornadoes—great extent of some gales of the ocean—great extent of the Natchez storm—ditto of the Cuba hurricane.

LECTURE XIV.

Of the Relations of the Atmosphere to Heat.

LAWS OF STORMS.

Introduction. Observed by the ancients that violent storms arise from the meeting of hot and cold winds—Consequences of such meeting. Recent interest awakened on this subject from the labors of Redfield, Espy, and Loomis; Reid, Piddington, Thom, and Dove. Great practical object in view.

Rotary Motion of Storms.

1. Appearance to spectators, and popular belief—small whirls and eddies frequently observed.

2. Whirlwinds produced by artificial fires.

3. Special examples of rotary motion, both on land and sea.

4. Curves formed by prostrate objects.

5. Comparative velocities of different parts of the whirlwind. Small progressive velocity.

5 9 991 6 66 1999

Section 18th 88

West India Isles under tropical sun liable to be disturbed —

Palestine 110° in shade in some parts — Going out of valley of Jordan toward Jerusalem becomes ~~[illegible]~~ cold. Extreme hot wind from East & South meet cold wind blowing from dead sea.

(A) Origin of this force. wind blows upon perpendicular obj in proportion to the sq of its velocity. 10 miles an hour gentle breeze ½ pound to sq foot — 100 miles an hour 50 pd sq foot. Prof Loomis believes in one case wind blew 600 miles pr hour — usually in hurricanes — from 100 to 300 pr hour. 75000 —

(B) Words often used interchangeably — Hurricane generic term — tornado land gale sea — whirlwind both — New tornados motion from S.W to N.E. 1839 Aug 31 New Haven tornado — Natchez 7 May 1840.

(b). Immediately before air very sultry — every particle from body is evaporated. Barometer falls — If falls suddenly look out —

Lecture 15. XV

Sir Isaac Newton

Descartes explained thunder storms on supposition of cloud falling upon cloud or compressing air. Wallace thought that the elements of gunpowder met in the air —

Leading Facts —

1st Belong to warm climates. seldom seen beyond 70 — never 75. More severe in Torrid than in Frigid. Peculiar form — cumulous convex summits — a little nimbus floats on the cloud & white veil over Ethiopian face" — Peaks of Alps exhibit signs of having been struck by lightning. One instance on record of thunder storm striking observed in Europe by height.

2 (a) By trigonometry one way. Better by counting interval between flash & sound.

Evening storms precursor of cool clear weat A

ming of rainy day — because the

ments of storm

Ocean Gales.

1. *Redfield's* theory of the gales of the Atlantic—Where they take their rise—their course—figure described by their paths—rotation on a vertical axis from right to left—hence great whirlwinds—their maximum diameter—rotary velocity—progressive rate.
2. Method of investigation pursued in determining these laws—general reception of the theory.
3. Practical rules suggested to navigators.

Waterspouts.

Description. Process of formation—singular clouds—agitation of the sea beneath—form of the pillar—height—attendant phenomena, winds, rain, snow, and hail. Effect of a discharge of artillery. *Cause* explained.

Philosophy of Storms.

1. Distinction between *proximate* and *ultimate* causes. What constitutes the proximate, and what the ultimate cause of storms.
2. Phenomena that are *easily accounted for;* as the violence, the density of the cloud, its occasional illumination and agitation, and great quantity of rain or hail.
3. Things *difficult to account for;* as their place of formation, course, and velocity of rotation.
4. Presence of *conflicting winds*, frequently from *all*, sometimes from only *two* points.
5. *Ultimate causes assigned.* Heat the most general cause.
6. Espy's views of the philosophy of storms.
7. Loomis's new methods of investigation, by tracing the progress, and learning the simultaneous phenomena throughout the entire region of a storm.

LECTURE XV.

Relations of the Atmosphere to Fiery Meteors.

THUNDER STORMS.

Introduction. Three subjects comprehended under the present head, namely, Thunder Storms, Aurora Borealis, and Meteoric Showers. Absurd views formerly entertained respecting the cause of thunder storms.

Leading Facts.

1. Thunder storms phenomena of *warm climates*—terrific in the torrid zone, hardly known in the frigid zone.
2. Thunder clouds peculiar in their structure—form—height—how to judge from the sound, of the altitude of a cloud and its distance from the spectator.

3. Our evening thunder storms from the *west*, morning from the *east*.

4. Thunder and lightning of *Volcanoes*.

5. Phenomena of "Castor and Pollux."

Philosophy of Thunder Storms.

1. Air when dry a non-conductor of electricity, but becomes a partial conductor when moist. Clouds conductors insulated by the surrounding atmosphere.

2. Evaporation and condensation copious sources of electricity.

3. Electricity manifests its violence only when its progress is opposed by non-conductors.

4. Electricity will follow the best conductors when they are sufficient to transmit it; otherwise it will divide itself among different conductors, according to their respective powers.

5. A conducting *surface* not sufficient, where the *substance* is a non-conductor.

6. Windows sometimes broken, and other effects produced by the *expansion* of confined air.

7. Winter thunder storms more dangerous than those of summer—those of the temperate, in proportion to the severity, more dangerous than those of the torrid zone.

8. *Origin* of thunder storms—how the common elements, as wind, rain, &c., are accounted for—sources of the electricity? Discharge from cloud to cloud—from clouds to the earth—whether from the earth to the clouds? Explanation of the leading facts. Prolongation of thunder explained—maximum length of the flash.

Protection from Lightning.

1. *Dangers.* Amount compared with those of steamboats and railways—less in cities than in the country—meeting houses in the country—trees standing in solitary situations—Powder Magazines—Effect on fish when small lakes are struck.

2. *Means of safety.* Dresses, beds, iron ships, and houses. Lightning rods. Construction—Reasons for believing that they afford adequate protection—different forms of rods and relative value.

LECTURE XVI.

Of the Relations of the Atmosphere to Fiery Meteors.

AURORA BOREALIS.

Introduction. Exhibitions of the Aurora in all ages. Ancient accounts compared with modern—historical notices.

Description.

1. *Varieties.* Twilight form—streamers—arches—corona—waves.

(4) volcanic thunder is occasioned by much
water & steam thrown up in cold regions suddenly
condensed & evolving electricity —

5] This phenomenon at sea gleaming of ends of
yards & masts - horses ears on land - fences
ends of palings. these arise from uncommon
humid state of atmosphere. Humid air produces
it because air when dry is perfect insulator & when
humid good conductor. Hence ~~one~~ carries off ~~a~~ of
the electricity naturally belonging to bodies

Philosophy of Storms —

clouds are prime conductors extending
over 10,000 acres —
2, vapo a substance mechanically and elec-
tricity is evolved - occur only in hot weather
because only then accumulation of electricity
can be. ~~Sr~~ 10 miles long flashes are

7 clouds are higher in warm
than in cold climates —

8] Electricity is not cause of
storm but effect - created by
condensation of vapor. - Common
elements wind rain accounted for, as
usual. Any evidence that lightning
strikes upward? Meeting House at Avon
struck. mud thrown upward & Stamford
the same. But not decisive there are
not wafers electrified with spark from a-
bove are thrown upward. No more reason that
mud is struck from beneath - so much indicates
violent repulsion. Thunder rolls long while
from first. ~~those~~ lightning has its course from
us. like file of soldiers ~~smile~~ ~~from~~ long shooting.
Maximum length of spark 10 miles

coming 100 miles above the Earth – It is not inconsistent with my views that it should occasionally dart down close to the earth –

22d volume of Journal –

three kind of periodicity – i.e. great Auroras – never come suddenly – first evening twilight – greatest brilliancy between 11 & 12 a diurnal & annual periodicity – most important to my theory is Secular periodicity – occur at intervals of 60 & 65 yrs – others of 22 or 25 – Dr Halley did not see one till very old. from 1780 to 1827 but few occurred no great ones

1st Electricity. 1st when thunder storms are most frequent Aurora not known – when not Electricity enough to make a tempest then Aurora. Again the electrometer is not affected by the presence of electrometer. Dr Brewster says it has never been doubted that electricity is the cause.

2. *Phenomena.* Luminous bank on the northern horizon—corruscations—merry dancers—crimson vapor—slaty color of portions of the sky—tenuity of the auroral vapor—whether attended by any sound?

3. Most of these phenomena, and the several varieties combined in auroras of the highest class. Examples.

CLASSIFICATION OF FACTS.

1. Belong to the *higher latitudes.* Frequency and splendor in the Arctic regions. Seldom seen below the latitude of 40°, except during one of the great visitations. Whether they occur in the Southern hemisphere?

2. *Extent.* Same aurora seen from Western Asia to the shores of the Pacific ocean—in London, Paris, and the United States—over all parts of North America.

3. *Height.* How estimated—what forms are best adapted for such measurement? Estimates by Dalton, Twining and others—different opinions relative to the height—placed very low by some—probability that the height is variable.

4. *Parallel Columns.* Their horizontal motion, constituting the "merry dances"—whether this motion is progressive or undulatory? Arches constituted from parallel columns.

5. *Magnetic properties.* Effect on the magnetic needle—position of the streamers and arches, with respect to the magnetic meridian—of the corona with respect to the dipping needle.

6. *Periodicity.* Occurs at a certain part of the night—great periods called *Visitations* of the aurora. Example of one from 1827 to 1848—characteristics of these great periods in the frequency and splendor of the exhibitions—interval between two visitations, from the middle of one period to the middle of another.

EXPLANATION.

What causes have been alleged to account for the aurora—what is required of a cause—distinction between hypothesis and theory. Hypotheses examined.

1. *Electricity.* Arguments stated—inadequate to account for the facts—two direct arguments against the hypothesis.

2. *Magnetism.* The presence of magnetic properties striking, but inadequate to account for the phenomena—does not explain the production of the auroral vapor, nor its origin—nor the periodicity.

3. *Reflection from Polar Ice.* Arguments conclusive against this supposition.

4. *True origin of the Aurora.*

Origin beyond the atmosphere, but the luminous exhibitions within it.

5. *Kind of matter* that composes the aurora. Reasons for believing it *ferruginous.*

6. Why the aurora is *periodical.* Astronomical relations implied by this fact.

LECTURE XVII.

Relations of the Atmosphere to Fiery Meteors.

METEORIC SHOWERS.

Introduction. Remarkable exhibition of Shooting Stars on the morning of November 13, 1833. Description of this phenomenon as witnessed at Yale College—general interest excited—accounts from all parts of North America.

Classification of Facts.

1. *Extent.* Seen throughout North America, including the West Indies, and from 10° E. of the coast of the United States to the shores of the Pacific.

2. *Duration.* Meteors more abundant than usual before midnight, but maximum from 3 to 4 o'clock. The November meteors always occur the latter part of the night, having their maximum at nearly the same hour.

3. *Varieties.* Fire-balls with or without trains—flakes of fire—and luminous masses of vapor.

4. *Sound.* Whether any was heard?

5. *Matter deposited.* Whether there was any?

6. *Apparent radiation of the Meteors from the constellation Leo.* Uniformity of this result in successive exhibitions.

7. *Velocity.* Compared with that of the earth in its orbit.

8. *Periodicity.* Recurrence of the same exhibition at the same time of year, namely, the 13th November. Other periods well ascertained, viz., in August, April, and December.

Explanation.

Hypotheses examined.

1. *Electricity.* Inadequate to account for the origin, or the phenomena, or the radiation from a given point, or the velocity, or the material, or the periodicity.

2. *Magnetism.* Why some ascribe the phenomenon to this agent. No proofs of its agency—inadequate to account for the facts.

3. *Terrestrial Comets.* Theory of *falling stones.* Proofs that the meteors of November could not be of the same nature—differently constituted—velocity too great.

Prof Olmsted. Lecture 17th

(A) If an appearance is within the atmosphere it will go on with the earth rotation - If not it will go with stars & [illegible] to western, & reach maximum between 3 & 4 o'clock anywhere —

(B) 40 miles - Prof Twining 4.0 miles —

LECTURE XVIII.

Relations of the Atmosphere to Fiery Meteors.

THEORY OF METEORIC SHOWERS.

Questions involved. Was the *origin* of the meteors within the atmosphere or beyond it? *Height* of this place above the surface of the earth? *Velocity* of the meteors? *Directions* of their paths? Cause of their *light* and *heat?* *Size* of the larger varieties? Height above the earth where they *disappeared?* Nature of the *luminous trains?* Of what kind of matter were the meteors constituted? Mode of existence *before they fell to the earth?* Relations of the meteoric body to the solar system? Why is the radiant point of the November meteors always in Leo, and that of the August meteors always in Perseus? And why do the showers recur at precisely *these times of year?*

EXPLANATION.

(A) 1. *Origin.* How we know whether a phenomenon in the sky is within the atmosphere, or beyond it—inference in the present case—further proof from the fact, that the maximum occurred at the same hour in different longitudes—also from the velocity of the meteors.

(B) 2. *Height.* Attempts to determine it—results.

3. *Velocity.* Various estimates—all too great to be produced by gravity.

4. *Direction.* Meteors moved in parallel lines—illustration—comparison with observation.

5. *Light and Heat.* The effect of condensation of the air—experiment with the air-match.

6. *Size.* How determined by comparison with the moon. Size if 110 miles off—size if 1 mile—Prof. Loomis's estimate.

7. *Altitude of the place of disappearance.* How estimated.

8. *Trains.* Their nature and extent.

9. *Constitution of the Meteors.* Tenuity, inflammability, transparency. Different from ærolites.

10. *Relations to the Solar System.* Meteoric body—its position in space—proofs of revolution—period—why not greater than the earth's period—whether equal or less—if less, some aliquot part—why not less than half a year—application of Kepler's law—why the apparent radiation is in Leo in November, and in Perseus in August.

11. Possible connexion with the *Zodiacal Light.*

12. *Reception* of this theory.

White 25
Deb 25
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ON

ASTRONOMY,

DRESSED TO THE SENIOR CLA

IN

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BY DENISON OLMSTED, LL.D.,

PROFESSOR OF NATURAL PHILOSOPHY AND ASTRONO

NEW-YORK:
ROBERT B. COLLINS.

1852.

OUTLINES

OF A

COURSE OF LECTURES

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☞ These Lectures are delivered to the Class after they have finished their recitations in the Text-book, and are therefore presumed to be acquainted with the Elements of Astronomy. To persons attending the course, who have not read this or some similar work, it is recommended to accompany the Lectures with the perusal of the author's "Letters on Astronomy."

In the delivery of the Lectures, the pupils are supposed to have these Outlines before them, and to accompany the lecturer through the successive heads of each Lecture. They will afterwards form the basis of the examinations, both public and private, on the same subjects.

Lec 2

Finally he made a catalogue of stars. a new star appeared in heavens & question came up whether heavens were permanent — so he catalogued stars 1022 of them.

Ptolemy was 100 years A. C. His almagest was a kind of Encyclopedia. Brought to us from Arabia by Crusaders

Aristotle rejected the hypothesis of preceding astronomers. Eudoxus Crystallin Sphere. (See Astronomy).

Julius Caesar had to send to Egypt to get astronomers to assist hi

OUTLINES

OF

LECTURES ON ASTRONOMY.

LECTURE I.

INTRODUCTORY.

PLAN OF THE COURSE—To consist chiefly of an exposition of the *Structure of the Universe*—Prefaced with a concise view of the *History of the Science*—Meaning of the phrase "Structure of the Universe," and how this subject differs from the elements of the science contained in the text-book—here all things considered in their relations to one grand whole, the System of the World. More interesting than the mere study of the elements, as the study of the classics is more interesting than that of grammatical rules, which are only preparatory. Things usually more interesting in their *relations*, than in their *individualities.*

Subjects of the present lecture, the different classes of astronomers—Laws of reasoning in astronomy—Pleasures and advantages of the study of the heavenly bodies.

I. DIFFERENT CLASSES OF ASTRONOMERS.—Great diversity and separate nature of the gifts that have characterized different astronomers—these to be considered in estimating the respective authority of each.

1. The *meditative class*, as Pythagoras, Copernicus.
2. The *mechanical class*, as Tycho Brahe, Sir William Herschel.
2. The *mathematical* class, as La Place, Le Verrier.
4. The class of *consummate* astronomers—those who have united these different qualities, as Kepler, Galileo, Newton.

II. LAWS OF REASONING IN ASTRONOMY.—Danger of resting on slight evidences or feeble analogies, when it is supposed full evidence is unattainable—Unreasonableness of skepticism and incredulity in regard to the established truths of the science. Advantages of having in view a few leading principles of reasoning.

1. The *possibility* of a thing but slight evidence of its reality.
2. The same causes produce the same effects—proper meaning and restrictions of this law.

3. The argument from *analogy* explained—its use and abuse in astronomy.

4. The argument from *authority*—to be received with caution, and of each astronomer in his own peculiar sphere of excellence.

III. Advantages of the Study.

1. To *commerce* and *navigation.*—Stars earlier guides than the compass—Now far more accurate—Example of the accuracy of the lunar method given by Basil Hall—Constancy of the motions of the heavenly bodies, and the perfection of instrumental measurement, as asserted by Dr. Bowditch.

2. To *chronology.*—Use of the precession of the equinoxes, of solar and lunar eclipses, of the situation of the pole of the earth among the stars for fixing remote dates. Command which the astronomer has over time, past and future.

3. In furnishing *standards of weights and measures.*—Importance of this subject in business transactions—Difficulty of finding perfect standards—Standards derived from an arc of the meridian, and from the pendulum.

4. *Intellectual* advantages.—Fulfils the two great purposes of education—to enlarge the mental powers, and to store the mind with important truths. Employs a variety of faculties—stimulates to new efforts—induces habits of profound reflection—favorable to the development of both the imagination and the intellect.

5. *Moral* advantages.—What class of astronomers have been devout, and what class undevout men—tendency of the contemplation of the heavens to awaken devotional feelings—Characters exhibited by great astronomers—tendency to inspire devotion and the love of truth noticed by the ancients, as Lucretius and Cicero—modesty of great astronomers asserted by Chalmers.

IV. Pleasures of the Study.

1. Delight experienced in contemplating the starry heavens with all the lights of modern astronomy.

2. Pleasure of recognising known constellations when in foreign lands.

3. Interesting reflections connected with the immutability of the heavens.

4. Fascinating nature of the study, both to the mathematician, who discerns new *laws*, and to the practical astronomer, whc discovers new worlds.

LECTURE II.

ANCIENT ASTRONOMY.

Two elaborate histories of astronomy by Bailly and Delambre. Four ancient nations that cultivated this science—antiquity of the study—two leading objects, Eclipses and Astrology.

Lec 2d Indebted to the French for histories chiefly. Bailly guillotined by Robespierre. Delambre succeeded him to the time of Napoleon. La Grange preceded him - and boasted that he had made all succeeding astronomers. Delambre notes many classical allusions - from Homer & Cicero.

Remarkable fact that not any most perfect but ē earliest cultivated. A perfect science before Philosophy was started - and reason is that they connected celestial phenomena with human events. Characteristic of man to penetrate the Future.

A. Importance attached to them arose from the popular opinion that they were connected with natural calamities. Chinese had a tribunal to take cognizance - of celestial phenomena. If they did not foretell correctly - or one occurred unpredicted they died. By their tables we can tell now the return of eclipses pretty accurately. 2 kind of Astrology. Natural foretold natural events as storms ec. Judicial destiny of man & empires. Horoscope aspect of the heavens on any event. & calculating the aspect of the heavens when any event occurs as birth ec. Heavens divided into 12 houses - equal parts - each a particular character impressed upon it - as house of riches - house of fame - And it affected a man's destiny which house rose at his birth - and still further it affected the destiny which planet was in the ascendant - of Mars - a warrior - the position of 2 planets with respect to each other made a compound character -

B (Chinese & Indians). Chinese tables mount up to 2500 Before Christ. They pretend to start when 5 planets were in conjunction - but they might calculate back & start hypothetically. By calculating eclipses they are at least 700 B.C. Brahmins allude to conjunction of 5 planets as well as Chinese. Their pretensions have been investigated - Bailly goes always upon supposition of their truth - Playfair was also. It is now agreed that they are not to be trusted. tables go back to 500 A.C. Later tables to 1000 A.C.

C). Their mode of life made them cultivate astronomy - sleeping on tops of their houses ec. When Alexander invaded India Callisthenes sent astronomical tables reaching back ~~to~~ 19 centuries. They invented the Saros, after 19 [illegible] Since the moon came into same relative position in the same part of heaven - hence began a new [illegible] of Eclipses - though it afforded the means predicting eclipses and was used till time of Hipparchus. (did not)

(D) Egyptians, make such progress as other nations

(E) Rose with Thales 7th century before Christ. 3 Schools. Ancient sages acquired their knowledge by going first to Egypt - then to Crete and oftentimes to Babylon - Pythagoras spent 30 years in Egypt & Babylon. Thales after his journey established his school at Miletus. His doctrines were obscure & many very absurd. Yet they knew many things. He knew rotundity of earth & cause of Eclipses.

(F) Pythagoras born Isle of Samos. & died at Sparta on way back to learn laws of Solon. Intended to found school at Samos, but they had put one man to death for teaching astronomy. So went to Crotona - often had 5 or 600 pupils at once. Great perceptions of truth. First caught idea of sun as center - revolution of Earth on axis - names of constellations. His diatonic scale - (See Philosophy). Hence music of Spheres. He first distinguished morning & evening star to be one body. He lived (500) B.C.

Alexander founded the school & all men united there) 300 B.C. it began. Must distinguish Ptolemies the princes from Ptolemy the astronomer. Hipparchus was born at ~~Alexa~~ Rhodes - great man - was more correct than others because first used angular instruments - very rude - greatest degree of accuracy - down to 10 m of an arc - now fractions of a 2". Introduced trigonometry - both plane & spherical - called inventor of Spherical. He lived 140 B.C. Compiled tables of sun & which he could calculate eclipses without Saros - He first discovered eccentricity of solar & lunar orbits although it must not be confounded with ellipticity. He discovered also precession of Equinoxes - also points of peri and aphelion called apsides - its revolution he detected. Moons nodes goes farther & farther west. This retrogradation of moon's node he ascertained - also length of year for by means of his instruments he could calculate when sun had reached its greatest declination - He came within 6 minutes - the same observation would enable him obliquity of ecliptic

(A) *Eclipses.*—Importance attached to them—supposed connection with impending disasters—how regarded among the Chinese.

Astrology.—Objects—rank of astrologers—pretensions of the art—horoscope.

(B) *Chinese and Indian Nations.*—High pretensions to antiquity—Eclipses recorded from a very high antiquity—Obliquity of the ecliptic determined—Astronomy of the Brahmins.

(C) *Chaldeans.*—Excellence of their observations—Discovery of the Saros.

(D) *Egyptians.*—Cardinal points indicated by the sides of the Pyramids—astronomical paintings and inscriptions.

(E) *Greeks.*—Long after the preceding nations—three successive schools, at Miletus, Crotona, and Alexandria. How the sages of Greece acquired their knowledge—how the modes of instruction in those ancient schools differed from modern methods—*Thales*—doctrines of his school.

(F) *Pythagoras.*—Extent and celebrity of his school—its date—Great truths foreshadowed to Pythagoras—Singular opinions entertained by him respecting the music of the spheres. State of astronomy in his time.

H. *Alexandrian School.*—Date—by whom established—great astronomers connected with it—*Hipparchus*—greatest astronomer of antiquity—when he flourished, and where—his discoveries—instruments—trigonometry, plane and spherical—tables of the sun and moon—eccentricity of the solar and lunar orbits—precession of the equinoxes—motion of the apsides—backward motion of the moon's nodes—exact length of the year, and obliquity of the ecliptic—his mode of calculating eclipses—catalogue of the stars.

Crystalline spheres of Eudoxus.

Ptolemy.—Greatest writer among the ancient astronomers—Almagest—Ptolemaic system of astronomy.

Romans.—The little attention they paid to astronomy.

Arabians.—The astronomers of the Middle Ages.

LECTURE III.

MODERN ASTRONOMY.—FROM COPERNICUS TO NEWTON.

Copernicus, 1473.—State of the age—Class to which he belonged—His system of the world—How his merits exceed those of Pythagoras—State of the science at that age—His proofs defective—His system compared with that of Eudoxus, and with that of Ptolemy.

Tycho Brahe, 1546–1473.—Seventy-three years after Copernicus—Birth and education—Class to which he belonged—His observatory—Number and value of his observations—What instruments he had, and what he was destitute of—His removal to Prague—his weaknesses.

KEPLER, 1571–1546.—Twenty-five years younger than Tycho Brahe—Birth and education—Mysterium Cosmographicum, its object and character—Characteristics of his genius—Alliance with Tycho. His *Laws*—the first discovered in astronomy—their importance. His eccentricities.

GALILEO, 1564–1546.—Eighteen years younger than Tycho, seven years older than Kepler—Early mechanical studies—Invention of the telescope—discoveries with it—confirmation of the Copernican system—Disputes with the Aristotelians—persecutions—Character of his genius—a "consummate" philosopher.

BACON.—Cotemporary with Galileo—their respective merits compared in philosophy and astronomy.

LECTURE IV.

MODERN ASTRONOMY.—FROM SIR ISAAC NEWTON TO THE PRESENT TIME.

NEWTON, 1642–1564.—Seventy-eight years later than Galileo—his rank among the human race—Saying of Bailly—Characteristics of his genius—*Three* capital discoveries—*Eight* great discoveries of the 17th century, 1. Pendulum. 2. Telescope. 3. Logarithms. 4. Micrometers. 5. Algebra applied to Geometry. 6. Kepler's Laws. 7. Calculus. 8. Universal Gravitation. Newton's inquiries into the philosophy of Light and Colors. Discovery of the Law of Gravitation—Why this is esteemed the most important principle in physics—What it has done for the cause of truth [accounts for the celestial motions—weighs the sun and planets—determines the exact figure of the earth, and of every body in the solar system—accounts for all the irregularities in the motions of the heavenly bodies—accounts for the tides, and determines their height at every place—suggests new fields of observation—anticipates the discoveries of the telescope, and corrects the most refined observations—determines the stability of the solar system—predicts the exact return of comets—and reveals to us new planets.] Whether the doctrine of universal gravitation will ever be superseded.

Personal qualities and virtues of Newton.

OBSERVATORIES.—Greenwich—Astronomers royal—Extent and accuracy of their observations—importance of these.

Societies.—Royal Society of London—Academy of Sciences at Paris—Astronomical Society of London.

Astronomers of England and France—Respective excellence of each—Other great astronomers of Europe—State of astronomy in our own country.

LECTURE V.

THE SUN.

Remaining part of the course intended to explain the structure of the universe—Embraces two inquiries, (1) What bodies compose the universe, (2) How they are arranged so as to form the system of the world. Order of subjects, the Sun, Moon, Planets, Comets, Stars, and Nebulæ—Mechanism of the Universe.

Sun.—Important relations to us as the source of light, heat, and attraction—Consequences were the sun withdrawn.

Diurnal Revolution.—Phenomena at the equator, and in different latitudes—Oppressiveness of his direct rays—*seems* directly overhead throughout the torrid zone—Opinion of the ancients that the torrid zone was uninhabitable—Provisions of nature for mitigating the intensity of heat. Phenomena of different latitudes from the equator to the pole—at mid-summer—at the equinoxes—at mid-winter—Appearances of the sun at these different stations at different seasons of the year—Phenomena of *twilight* in various countries—lasts all night at midsummer beyond 48½° of latitude—length of twilight in our latitude—length of the shortest night—ditto of the longest night. In travelling round the earth eastward, a day gained—westward, a day lost—Case of two travellers going round the earth, and returning to the same place—also, when meeting at some other point, as at the Sandwich Islands—Case of ships, and of missionaries—Effect of these principles on the *Sabbath*—When the Sabbath begins—Case where the twilight lasts all night—where it is continual day—where the parties meet on opposite sides of the earth. When is the design of the ordinance fulfilled?—Reasons for consulting expediency.

LECTURE VI.

THE SUN.

Annual Revolution.—Mode of distinguishing between the diurnal and annual motions of the sun—cause of each explained—Compatibility of the two motions—Solar days longer in winter than in summer—Sun eight days longer on the north than south of the equator—why—Greater nearness in winter compensated by the shorter time, so as to preserve an equality in the distribution of heat.

Obliquity of the Ecliptic.—Modes of finding it practised in ancient and in modern times—Its amount recorded at different epochs—Its annual variations—Present amount.

Rotation of the Sun.—Period—Telescopic appearance of the sun.

Spots.—Description—extent—cause.

Galileo's hypothesis.—Fiery sea—Volcanic scoriæ—objections.

Lalande's.—Recession of the fiery sea—Solar mountains and valleys—objections.

Herschel's views of the nature and constitution of the sun—Supposed atmospheres—whence the light and heat—false reasoning—whether the surface of the sun is in a state of combustion or of ignition.

LECTURE VII.

THE MOON.

Its uses for light, for tides, for months, and for longitudes—comparative nearness—Distances of the other heavenly bodies measured by millions, of the moon by thousands—Appearances to the naked eye of its phases, and of its light and shade, when full.

Revolution around the Earth.—Changes in its path, its velocity, its nodes—Numerous irregularities—their general cause—why so much more numerous in the moon than in any other of the heavenly bodies—Pains taken to perfect the lunar tables—different means employed for this purpose.

Telescopic Appearances of the Moon.—Directions for viewing the moon—Magnifying powers employed for different purposes—Successive appearances at different ages—Best view at quadrature. Objects to be particularly noted.

1. Broken surface—extreme irregularity.
2. Appearance of the *terminator*—Single mountains described—Height of the lunar mountains.
3. Circular chains—long ridges.
4. Radiations from Tycho, Kepler, and Copernicus.
5. Valleys and craters—resemblance of these to volcanic craters on the earth—mode of formation.

Whether the Moon has an Atmosphere?—Want of evidence

—None seen in eclipses—Supposed appearance of twilight—No change of place by refraction in a star undergoing occultation—Atmosphere, if any, very small and rare.

Whether there is Water in the Moon?—Places named seas not such—no clouds nor fogs—no atmosphere of watery vapor.

Volcanoes.—Proofs of their existence—objections considered.

Lunar Influences.—Supposed influence on the weather—on diseases—on vegetables.

Whether we can ever hope to see lunar inhabitants or their works?—Limits to the powers of the telescope. Effect of applying different magnifiers from 100 to 10,000.

LECTURE VIII.

THE PLANETS.

In nearness, next to the [illegible]—the sun, moon and planets, compose one family in the stellar universe. Influence of the planets upon our world slight, though considered in the days of astrology as very great.

Number.—How many were known to the ancients—Analogy sought by Kepler in the five regular solids—Whole number, including the earth and moon, seven—Supposed by the Aristotelians to be necessarily seven—Reasoning of the Roman doctor against Galileo's discovery of Jupiter's satellites. Uranus added in 1781—Ceres, Pallas, Juno, and Vesta, about the commencement of the present century—more recently, Astræa, Hebe, Iris, and Flora.

Remarkable discovery of Neptune by Le Verrier—his reasons for supposing its existence—Mode of investigation—Elements determined previous to observation—Discovery with the telescope—Similar results obtained by Adams—Respective merits of these astronomers—How their results have been modified by Walker and Peirce—This planet seen by Lalande in 1795, and recorded as a fixed star—Traced back to this place by Walker.

Great distance of Neptune from the sun—Long period of revolution—Magnitude, density, and other elements.

Appearances of the different planets to a spectator on the sun, in regard to size, light, velocity, &c.

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—None seen in eclipses—Supposed appearance of twilight—No change of place by refraction in a star undergoing occultation—Atmosphere, if any, very small and rare.

Whether there is Water in the Moon?—Places named seas not such—no clouds nor fogs—no atmosphere of watery vapor.

Volcanoes.—Proofs of their existence—objections considered.

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In nearness, next to the sun and moon—the sun, moon, and planets, compose one family in the stellar universe. Influence of the planets upon our world slight, though considered in the days of astrology as very great.

Number.—How many were known to the ancients—Analogy traced by Kepler to the *five* regular solids—Whole number, including the earth and moon, *seven*—Supposed by the Aristotelians to be necessarily seven—Reasoning of the Roman doctor against Galileo's discovery of Jupiter's satellites. Uranus added in 1781—Ceres, Pallas, Juno, and Vesta, about the commencement of the present century—more recently, Astræa, Hebe, Iris, and *Neptune*.

Remarkable discovery of Neptune by Le Verrier—his reasons for supposing its existence—Mode of investigation—Elements determined previous to observation—Discovery with the telescope—Similar results obtained by Adams—Respective merits of these astronomers—How their results have been modified by Walker and Pierce—This planet seen by Lalande in 1795, and recorded as a fixed star—Traced back to this place by Walker.

Great distance of Neptune from the sun—Long period of revolution—Magnitude, density, and orbit eccentricity.

Appearances of the different planets to a spectator on the sun, in regard to size, light, velocity, &c.

LECTURE IX.

PLANETARY LAWS.

Distinction between laws and individual facts—No laws in astronomy known to the ancients—the first those discovered by Kepler—Our knowledge advanced rapidly by laws, slowly by individual facts. Laws reveal systems and comprehensive designs.

1. Kepler's Laws.—History of their discovery—Known to Kepler as matters of fact, and not of demonstration—First demonstrated by Newton.

(1) *Figure of the orbits*—how these differ from the *eccentric* orbits of the ancient astronomers.

(2) *Equality of Areas* described by the radius-vector—Great utility of this law in calculating elements.

(3) *Distances and periodic times.*—Value of this discovery—Exultation of Kepler on finding it—Reduces several of the most important particulars of the planets to exact numerical relations.

2. Law of Universal Gravitation.

3. Numerical Relations of the Planets.—Derived from Kepler's third law and the doctrine of universal gravitation—Velocities, distances, periodic times, and gravitation towards the sun, all adjusted to one another, like the hour, minute, and second hands of a clock—Relation between mass and velocity—Velocity, distance, time, and force of gravity, compose a series in geometrical progression of which the first term is the ratio—How derived from Kepler's third law and the law of gravitation. Any one of these terms being given, the rest may be found—illustrations—Method of finding the masses and densities of the planets explained and illustrated.

LECTURE X.

PLANETARY LAWS.

1. Great Mechanical Laws which belong to every system of bodies, connected together by mutual relations, but perfectly verified only in the heavenly bodies.

(1) Conservation of areas.

(2) Conservation of the center of gravity.

(3) Principle of Least Action.

LECTURE IX.

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LECTURE X.

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1. General Mechanical Laws which belong to every system of bodies connected together by mutual relations, but [illegible] verified only in the heavenly bodies.

(1) Conservation of areas.
(2) Conservation of the centre of gravity.
(3) Principle of Least Action.

2. Motion in an Orbit under Two Forces.

Experiment with a suspended ball—Effect of gravity alone—of the impulsive force alone—Gravity accounts only for the constant deviation from a straight line—A primitive impulse indispensable—No cause for it now existing—Must have been applied at some previous period of its existence, and then withdrawn—Argument for a First Cause—Evasion of this argument—how obviated.

Why a planet or a comet turns about at its aphelion, and what keeps it off from the sun at its perihelion.

3. Comprehensive View of the Solar System.

(1) Of the bodies composing it.

(2) Of their relations to one another.

Resemblance of the subordinate systems to the whole—Uniformity of plan throughout—General motions from west to east—Exception to this uniformity in the satellites of Uranus.

Constancy of the law of gravitation.

4. Stability of the Solar System.

"Problem of the three bodies"—Causes of disturbance existing in the system—Stability of the system first determined by La Grange, and confirmed by La Place—Its mathematical expression [The mathematical formula which expresses the effect of all the perturbations, is contained in the sines and cosines of arcs, which necessarily vary between zero and radius]—the perturbations oscillate about a mean value—Grand axes always constant—also the periodic times.

5. Proofs of the Copernican System.

Doctrine stated.

1. *That the earth revolves on its own axis.*—More simple—Analogy—Spheroidal figure—Diminished weight at the equator—Bodies fall eastward of their base.

2. *That the planets, including the earth, revolve about the sun.*—Phases of Mercury and Venus—Greater symmetry of the movements and orbits of the superior planets when referred to the sun as a center.

3. That the motion of the *earth* around the sun is especially indicated—by analogy—by Kepler's law—by the retrograde motions of the superior planets—by the phenomena of meteors

LECTURE XI.

HABITABILITY OF THE PLANETS.

Circumstances unfavorable to the doctrine—Extremes of heat and cold—of light—of gravity—Want of atmospheres—Such beings as inhabit this earth could not inhabit the planets, but still some reasons for thinking that they have their appropriate inhabitants.

1. Reasons for believing that the planets were designed for the same purposes as the earth.

(1) From the uniformity of *plan* manifested throughout nature.

(2) From the fact that the earth is a member of a system, and not *the* leading member.

(3) From the consideration that all things have their *use*—illustrations of this point—Uses of the planets to our earth very slight.

In order to learn the purpose for which the planets were made, we inquire,

2. For what purposes the *earth* was made.

(1) Animal life.—Its multiplication in every part of the earth—Great range from the whale and the elephant to the infusoria—Multiplication of life even in the polar seas.

(2) Not animal life in general, but *Man* the great purpose for which the world was made. All things for his use.

First, the *powers* of nature.

Secondly, the *productions* of nature.

Thirdly, the beauty and sublimity of nature.

Fourthly, the power of exalting nature—of developing its powers—of compounding and forming new creations.

(3) Argument from *analogy* applied to the planets to prove that life is their *general*, and intelligent beings their *special* purpose.

(4) Direct evidences that the planets are inhabited.

LECTURE XII.

COMETS.

1. Historical Notices.—Pythagoras—Aristotle—Tycno—Newton—Circumstances that render them intrinsically interesting—History of Halley's Comet.

2. Laws of their Motions.—In what respects they are alike, and in what unlike those of the planets.

3. Determination of the Orbit of a Comet.—Nature of the difficulty—Method of finding the elements—These may serve to identify the comet with one that has appeared before, but do not give the *periodic time*—How the time is ascertained—Exemplified in Halley's comet. The *approximate* time being found, to find the *exact* time—Number and sources of the perturbations—Laborious nature of the calculations—Exemplified in the returns of Halley's comet in 1759 by Lalande, and in 1835 by Pontecoulant.

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Allowed is the Solar System to waggle a little like Rail car — It is limited — has its maximum and minimum. whenever acceleration would involve hazard arrested — when it wouldn't, it is not arrested — Thus revolution of line of apsides does not. gravitation naturally produces this effect.

① Mercury comes so near the sun no place where wouldn't boil some part of the year — other planets too far off. Light would be at Mercury insupportable — others disappear in the Sun's light — as Saturn — Jupiter as an Evening star &c Light decreases as square of distance increases. At Uranus couple of 1"! yet a small fragment of the sun appears light as in eclipse ~~but~~ cheerless light. Again gravity is inconsistent with idea. Man 200 here 5600 on Sun. Why the Moon the mass so small and density so small, that a man who can jump ~~to~~ a yard high here could leap 60 there. Again want of atmosphere. Can nearly prove there is no atmosphere — If any very slight. The proof not decisive as to any possessing atmosphere —

(1) For the question

(1) Strikes us as an inconsistency that the earth alone should be inhabited. the uniformity is evidence it is a key to the works of nature. Suppose a stranger to come into view of solar system — finding the Earth inhabited would conclude the others were

2 unphilosophical to suppose the earth a leading member — whereas only one in a system —

(3). It is said that Hippocrates in dissecting an animal finding a part whose use he never before perceived laid down his knife and offered a Hecatomb to the Gods. So everything has its use. All planets useless unless inhabited.

2 Why Earth made

(1) Support of animal life. More obvious when we consider the profusion of it. 200,000 species. Life is multiplied beyond imagination.

(2) Man the only object. All arrangements with reference to man: thus obvious powers —

Heat, light &c ~~as~~ animals can't employ it ~~[illegible]~~ Powers of nature given to man alone, the productions of nature given to man —

particular ones given to animals alike to man.
The animate creation itself is given to man.
Life and happiness of man object of this world and the
same analogy would lead us to conclude that life
and happiness object of other planets.
(4) Positive evidence. There is nothing. If anything
conclusive it is this; there are arrangements which
seem to indicate it. As moons of Jupiter arranged
as to throw their maximum light on the planet.

Lec 12.

One of the marvels of creation.
Historical notices. Pythagoras first expressed the
opinion that they were part of the Solar system
This was supplanted by opinion Aristotle that
they were monsters generated in the atmosphere
and continued till Tycho Brahe found they
had some parallax and referred them to the
Solar system. Newton found them subject to laws
of gravitation.
2 Comets. In Feb 1843 a great one came. It
was one of the most, and in some respects most remark-
able. It was first seen at noon. Very remarkable
for its approximation to the sun & many thought
it touched the sun. Others said it grazed it – and
was about 90,000 miles from the sun. The train
reached more than 100,000,000 miles from earth. If
it had been round the Earth it would have over
shadowed the Earth. ~~200~~ years to revolve. Halley
went 300,000,000 miles. If 175 years a period it
would go 6,000,000,000 miles from the ~~20~~ sun.
Halley's more remarkable still.
It was first whose return was successfully predicted.
It came again in 1835. Looked for with great interest
for its return often mentioned in history.
2° Motions of comets & planets alike. Both subject
to laws of gravitation. In other respects unlike. Planets
nearly circular. Comets erratic. Upon their rel-
ative velocity depends the amount of eccentricity. Again
in physical constitution very attenuated. Again their
motions very slow when far, come to very then
near the sun very rapid – their direction vary – some-
times with the signs sometimes contrary – sometimes
ver angle with ecliptic – others [illegible] planets
niform – direction with signs &c

How far the predictions of astronomers, on the last return, were fulfilled.

4. Physical Nature of Comets.—Constitution of the three several parts—Extent and tenuity of the train—Exceedingly small mass—Whether so rare a body would obey the laws of gravitation and projection—Whether the matter is self-luminous—Hypotheses to account for the formation of the tail—by the impulse of the sun's rays—by the action of heat—Difficulties attending all hypotheses yet proposed.

5. Dangers.

(1) Dangers in various parts of nature, as from extremes of heat and cold—from the perturbations of the moon and planets—Guards set to prevent mischief—Whether any guards can be detected in the case of comets. Two especially, in the swiftness of their motions, and the smallness of their masses—also from the fact that they are subject to laws.

(2) Consequences were they to strike the earth—Threatening circumstances attending the great comet of 1843.

(3) Question of a *resisting medium*, and its final effect upon the motions of comets.

LECTURE XIII.

FIXED STARS.

Solar system the chief object of attention to astronomers before Sir William Herschel—His forty-feet telescope—Rosse's fifty-feet *reflector*—Great *refractors* recently constructed, as the Pulkova, the Cincinnati, the Cambridge instruments, respectively—Comparative advantages and disadvantages of reflectors and refractors—peculiar advantages of large telescopes.

Fixed stars.—Why so called—Immutability of the constellations, contrasted with the mutability of terrestrial nature.

Twinkling of the stars explained.

Catalogues of the stars—by Hipparchus, Tycho, Flamsteed, Lalande—Astronomical Society—Bessel's zones—Berlin charts.

Distances.—Eight of the greatest discoveries in astronomy:

1. Kepler's Laws. 2. Law of Universal Gravitation. 3. Weighing the Sun and Planets. 4. Demonstrating the Stability of the Solar System. 5. Measuring the Velocity of Light. 6. Exact Determination of the Periodic Time of a Comet, as Halley's. 7. Discovery of the Planet Neptune. 8. Measuring the Distance of a Fixed Star.—Proofs of the immense distance of

the stars, from the want of parallax—from the effect of the largest telescopes.

Researches for an *annual parallax* by Flamsteed, Bradley, Brinkley, Bessel—Observations of Bessel on 61 Cygni—Amount of its parallax—Whether it may not be fallacious—Illustrations of the distance of 61 Cygni by the time occupied by light—bv a railway-car.

Supposed parallax of Alpha Centauri—of Sirius.

LECTURE XIV.

SYSTEMS OF STARS—NATURE OF THE STARS—FINAL PURPOSE.

1. Systems of Stars.

(1) *Double*, *triple*, and *multiple* stars.—Great number of such groups—Sometimes merely *optically* double—Revolutions of the binary stars—Proof which they afford of the extent of the law of gravitation.

(2) *Clusters.*—Pleiades—Beehive—in the head of Orion—in the sword-handle of Perseus.

(3) *Nebulæ.*—Description—Various forms—Extent—Resolvable and irresolvable—Whether this distinction is absolute or relative—Bearing of recent discoveries of the great telescopes on this question—Researches of Mason and Smith on nebulæ—Observations of Sir John Herschel in the southern hemisphere.

(4) *Galaxy.*—Its figure—Constitution according to Sir William Herschel—The relation of our solar system to it—How our position in it is determined.

2. Nature of the Stars.

(1) Material bodies—obey the law of attraction.

(2) Larger than our earth—Sum of the masses of both the stars in 61 Cygni half that of the sun—Orbit twice that of Uranus—Period 540 years—Sirius equal to two suns, or, according to Wollaston's experiments upon its intrinsic light, to fourteen suns.

(3) Light of all has the same velocity—Velocity uniform—Constant of aberration the same in all.

(4) Light of the stars not polarized, therefore direct, and not reflected.

3. Final Purpose of the stars.

Not for ornament—not to give light by night—not for navigation—Are suns of other systems—Uniformity of plan in the works of creation—Purpose of our sun for light, heat, and attraction to planetary worlds—Life tne great object of these—All for intelligent, immortal beings.

LECTURE XV.

MECHANISM OF THE HEAVENS.

1. Propriety of reasoning from the uniformity of plan in nature —Deducing what we cannot see from what we do see.

2. What we actually see.

(1) Subordinate systems, as Jupiter and his satellites.
(2) The solar system.
(3) The binary stars.
(4) Higher systems in groups, clusters, and nebulæ.

3. Probable prevalence of the law of universal gravitation through the universe.—Consequences of such a law—Analogy leads us to expect revolutions—Mere attraction without it tends to ruin—Proper motions detected among the stars—These motions of revolution.

4. Grand machine of the universe.—Probability that it is constructed after the model of the solar system—Its actual organization.

LECTURE XVI.

MAEDLER'S CENTRAL SUN—NEBULAR HYPOTHESIS—CONCLUDING REFLECTIONS.

Center of the Universe(?)—Attempts of Maedler to find the center about which the stars of our firmament revolve—Fixed in Alcyone, the principal star of the Pleiades—Reasons for selecting this point—Whether any thing more is necessary than a common center of gravity—Movement of the solar system, and of various other stellar systems in respect to this point.

Nebular Hypothesis.

1. Herschel's views of the progressive state of the nebulæ—Whether changes now take place within short periods—Mason's researches on this subject.

2. La Place's hypothesis of the formation of the solar system —Principal object to account for the revolutions all in the same direction—Principles of it stated—Supposed illustration by experiment—Phenomena explained by the hypothesis—Comets not included—*Objections* considered—whether the doctrine is necessarily atheistical—whether such a mode of formation is possible—whether probable—Backward motion of the satellites of Uranus —Bearing on this hypothesis of late telescopic discoveries among the nebulæ.

CONCLUDING REFLECTIONS.

1. Relations of Astronomy to Natural Theology.

2. Place which our world and which man holds in the universe—Supposition that both are too insignificant to be objects of high and peculiar interest to the Creator, considered.

3. View which the Creator took of his own works when he pronounced them "very good."

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